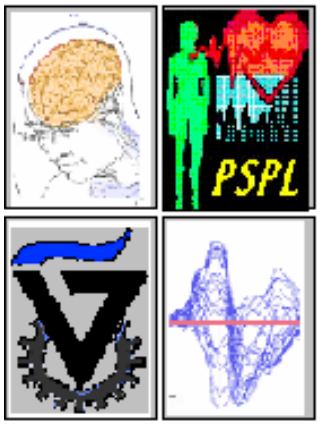
TECHNION – Israel Institute of Technology
Department of Electrical Engineering
The Physiological Signal Processing Laboratory

Subjective VS Objective Pain Assessment

Presented by: Michael Dvorkin
Ilya Fux

Supervised by: Dr. Danny Lange



The Kasher Contest – In memory of Yehoraz Kasher

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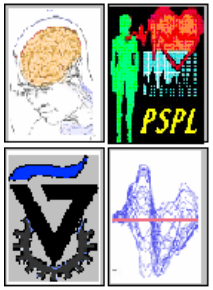
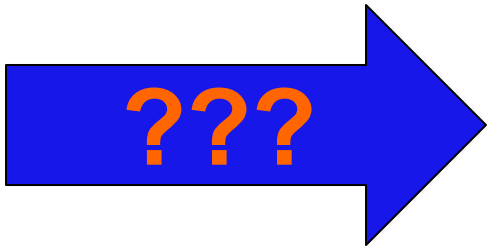
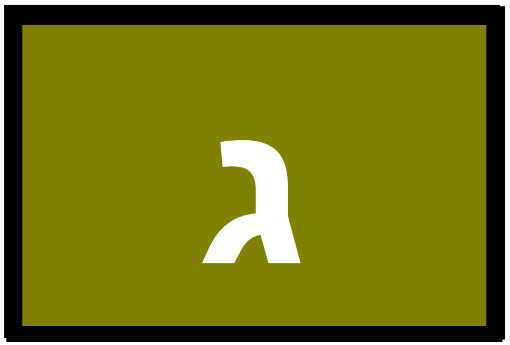


The Problem

Objective Pain measurement Possible?





<u>Goal</u> – Check feasibility of an objective pain measurement system

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Previous Efforts

Physiological phenomena

Verbal scales

MRI based

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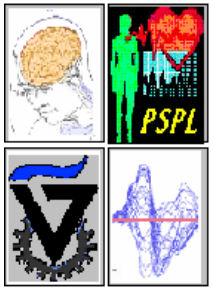
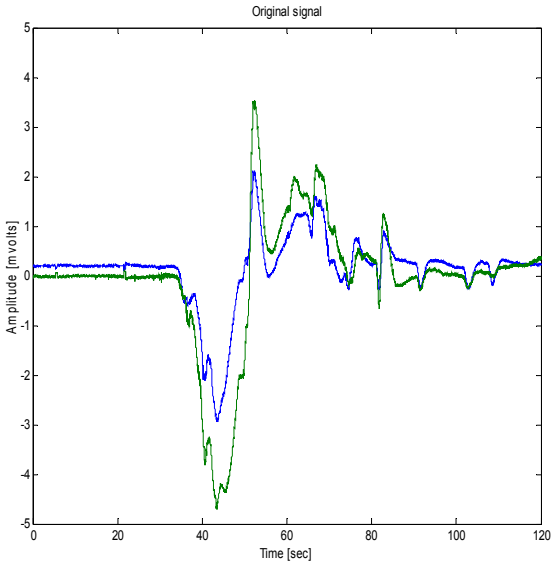


Solution Proposal

- Recent discovery - pain sensation is followed by an **electrical activity** on subjects forehead.
- Probably, caused by the **parasympathetic nervous system**.

Phenomenon Properties

- **Difficult** to measure
- Strongly **varies** from subject to subject
- Amplitudes – up to **5mV**
- Low band signal, **0.5Hz - 5Hz**



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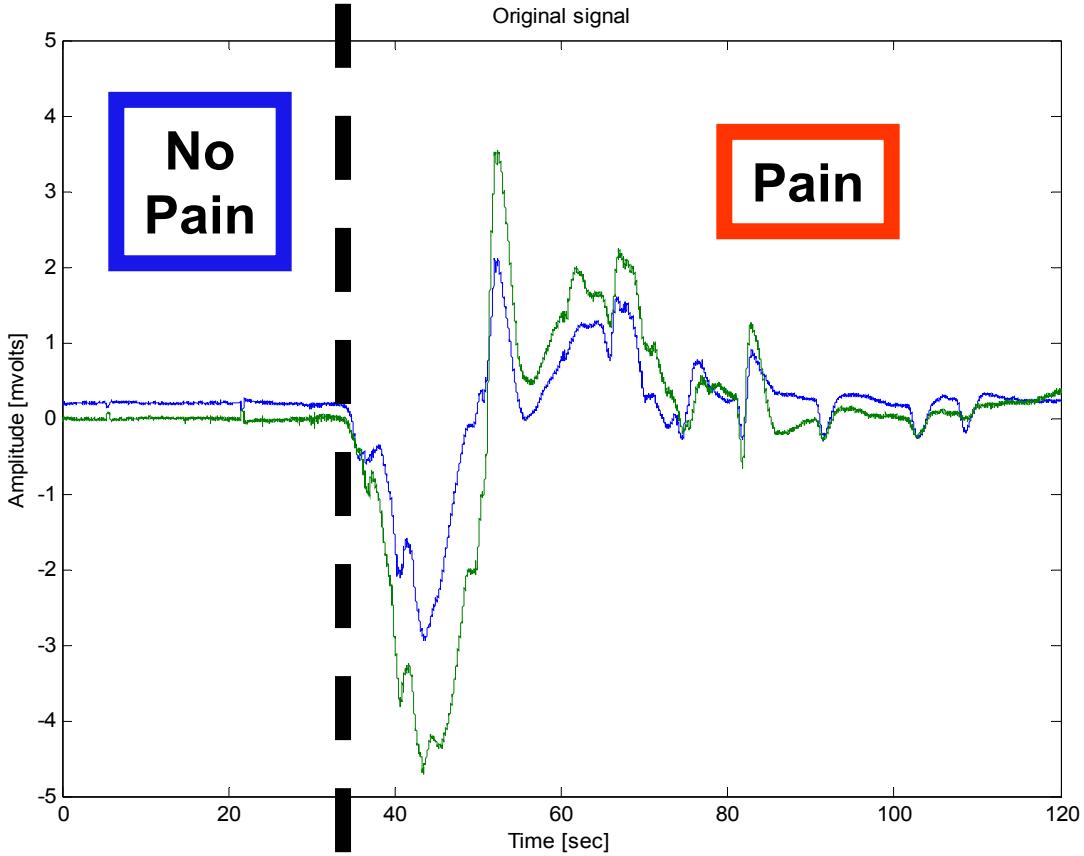
Typical Signal



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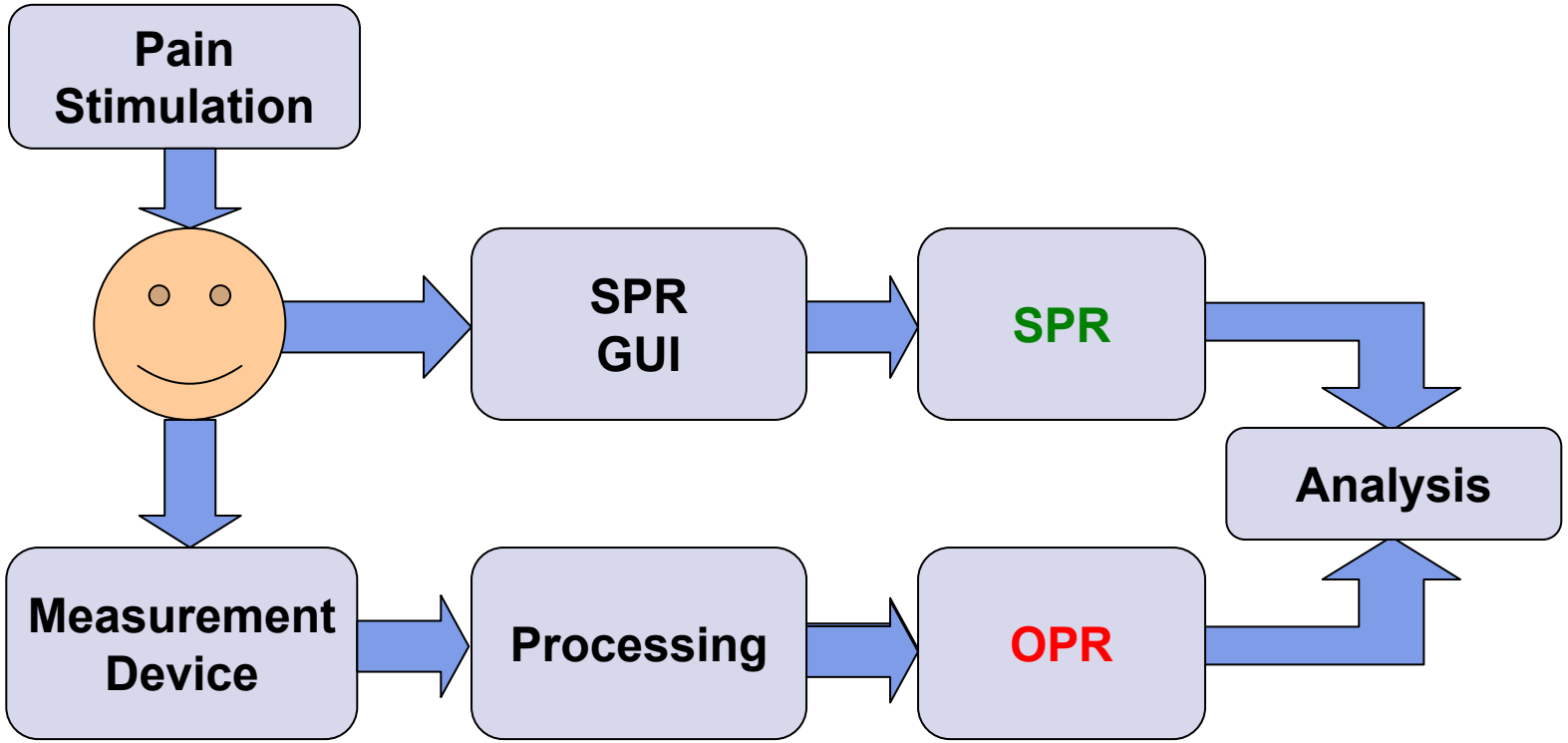
Basic Approach



SPR – Stands for Subjective Pain Report
OPR – Stands for Objective Pain Report

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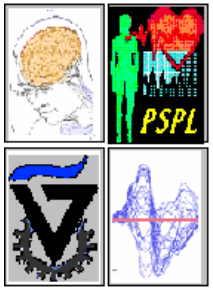
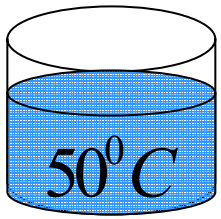


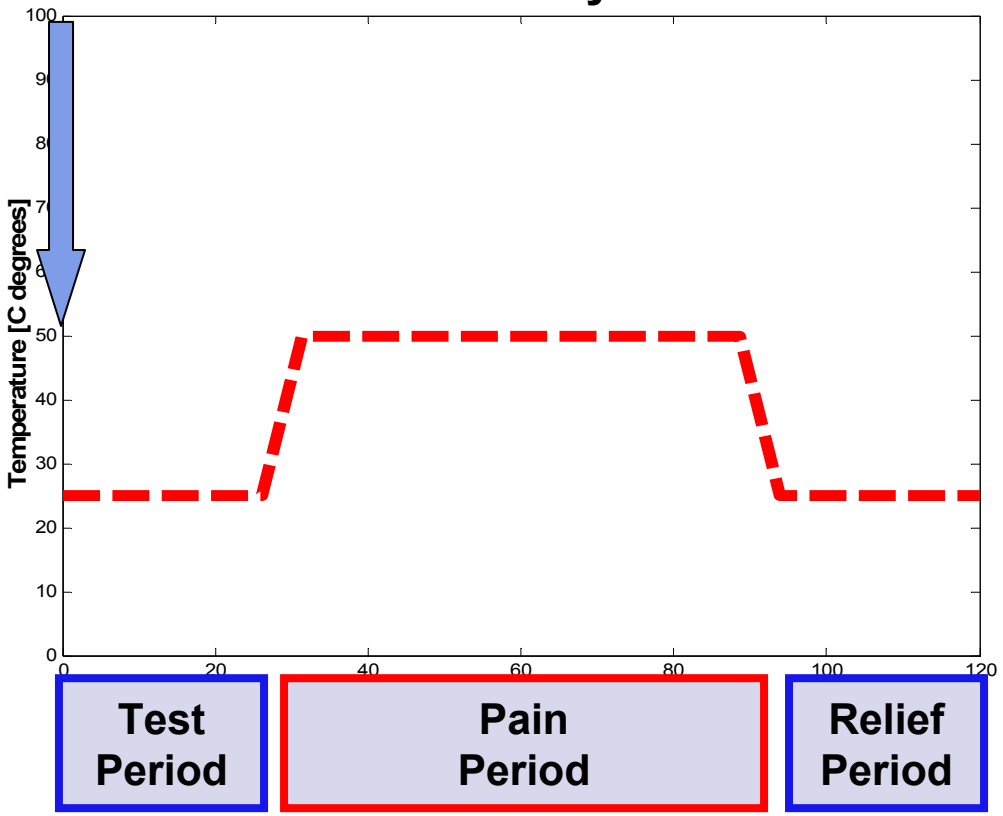
Pain Stimulation

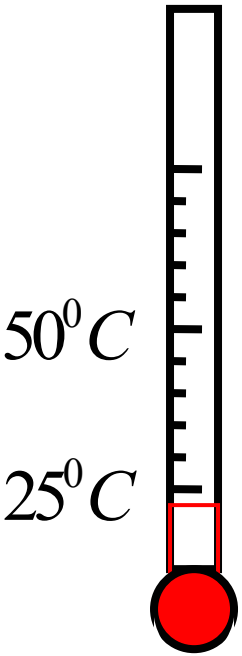
A heat based Pain source was used.
Hurt regions: Hands (Left & Right)



Water

Pain source Dynamics





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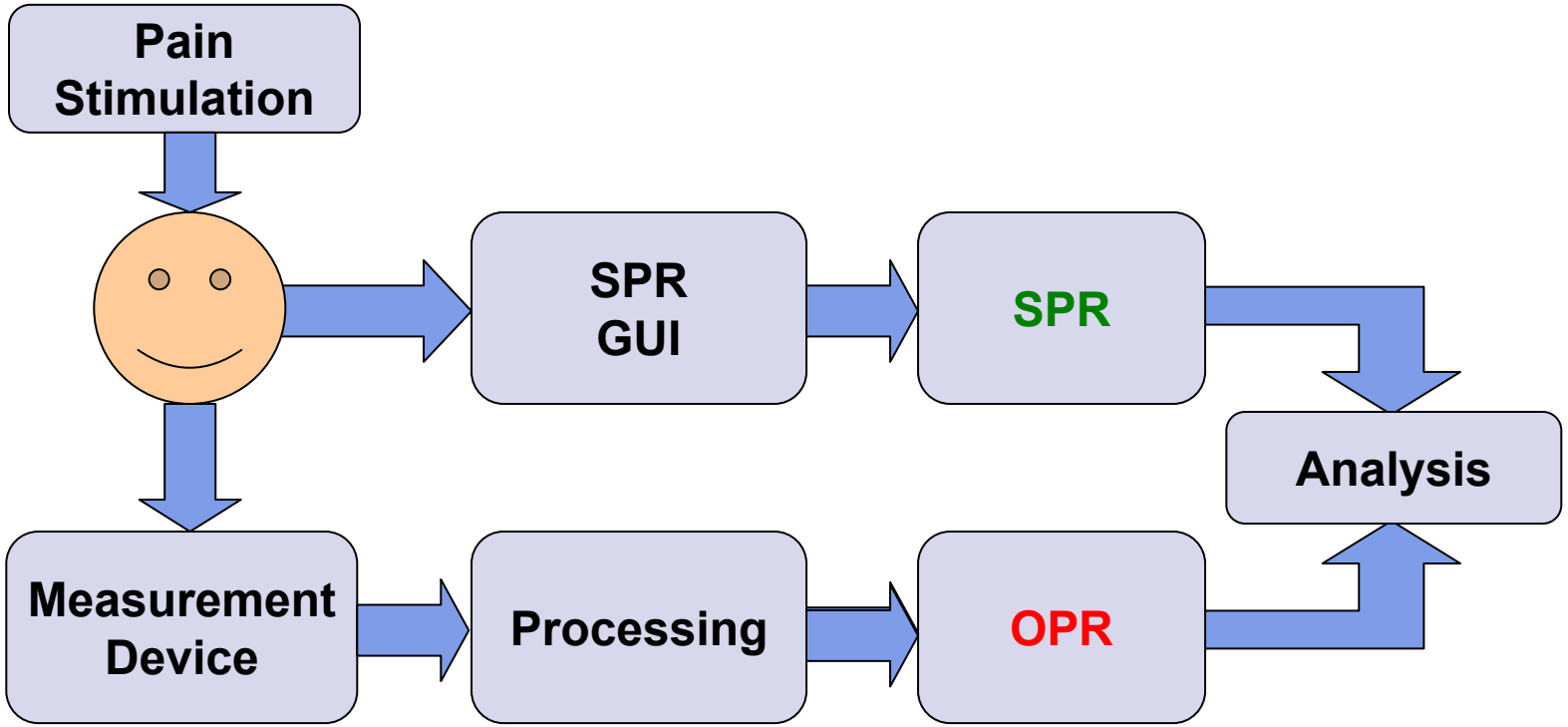

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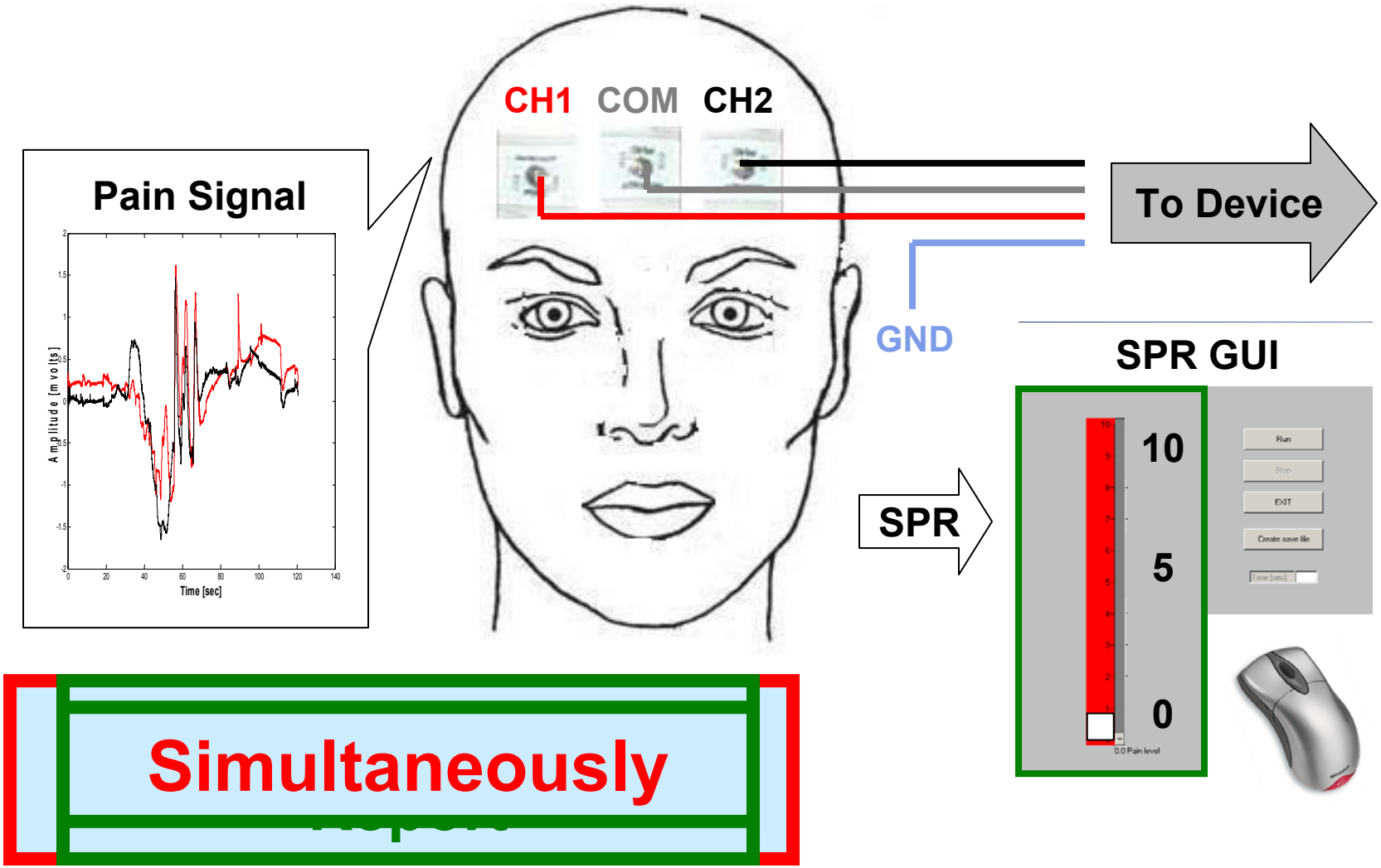
Experiment Structure



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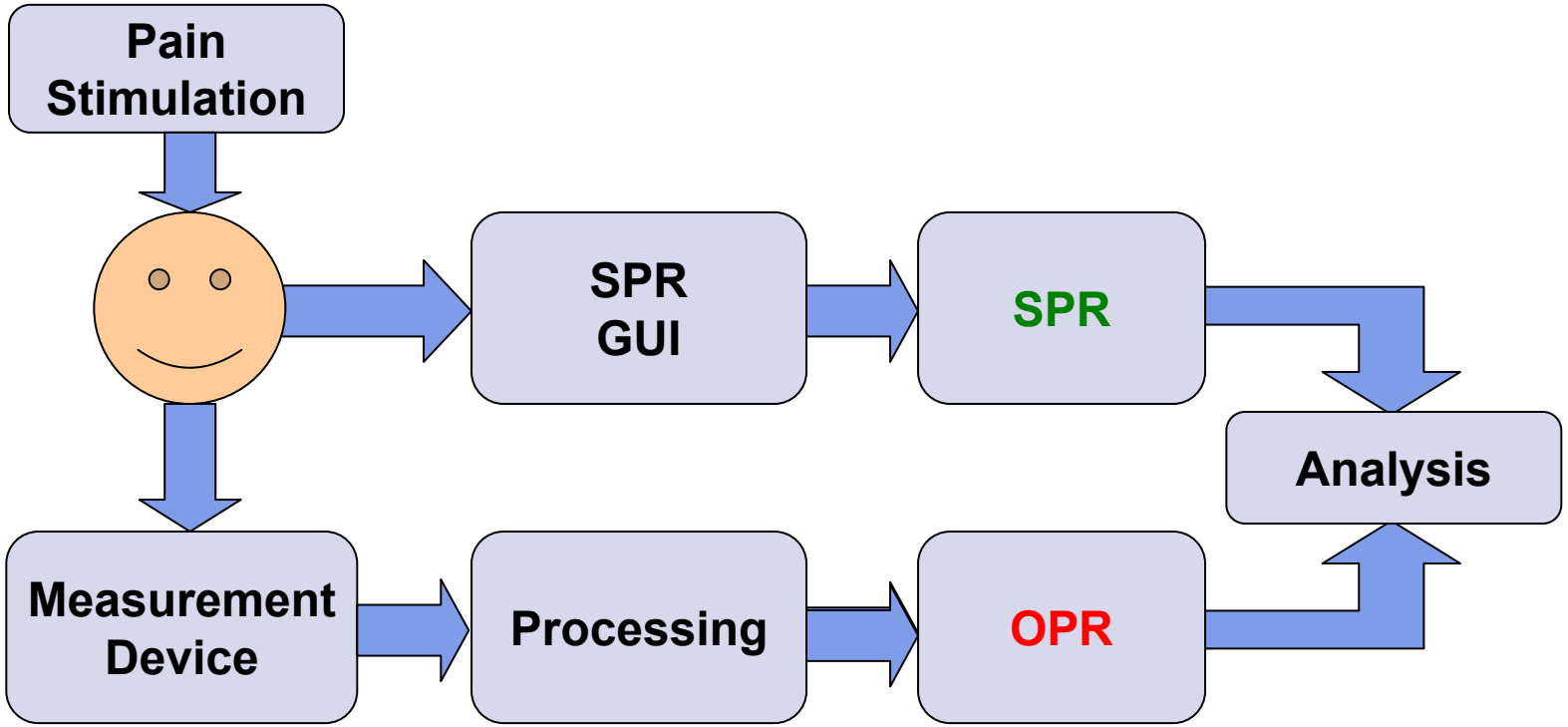

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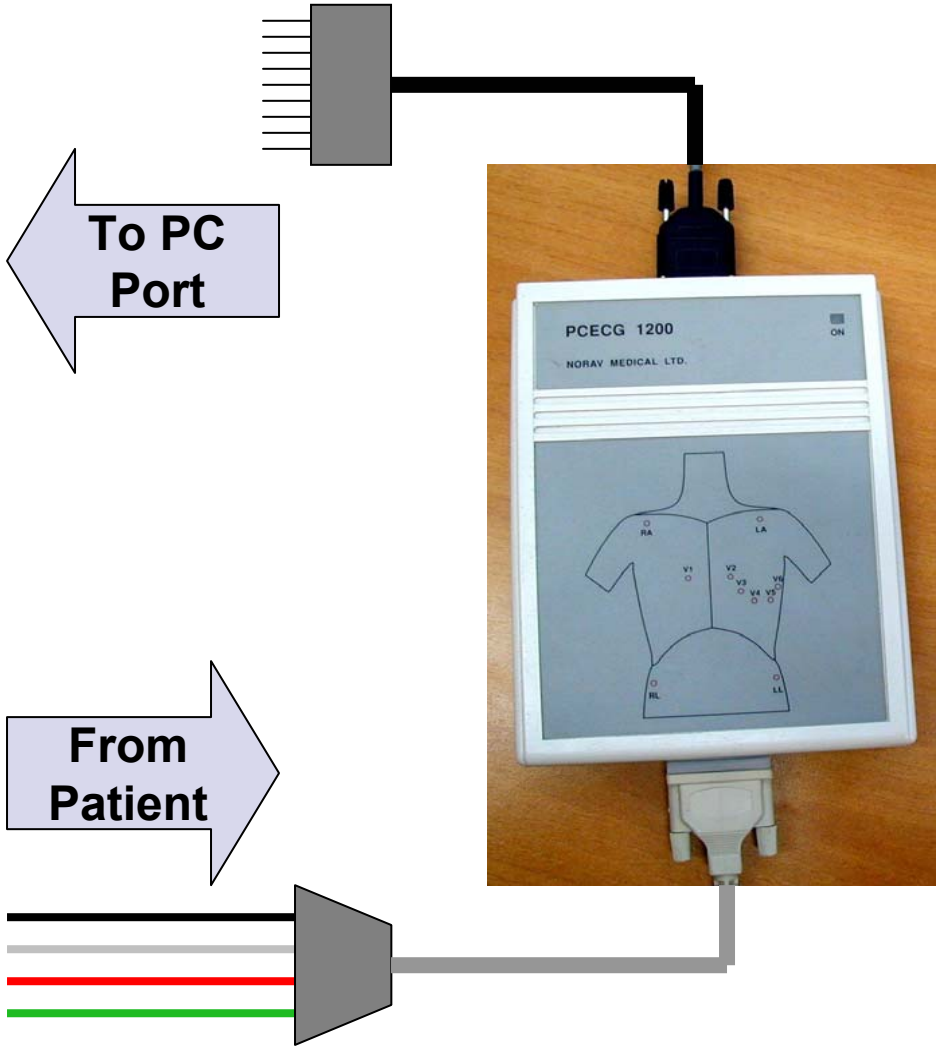
Measurement Device



PCECG 1200

NORAV MEDICAL LTD.

Advantages

- **Portable**
- **Friendly**
- **Cheap (1600$)**
- **PC software**
- **Safe**

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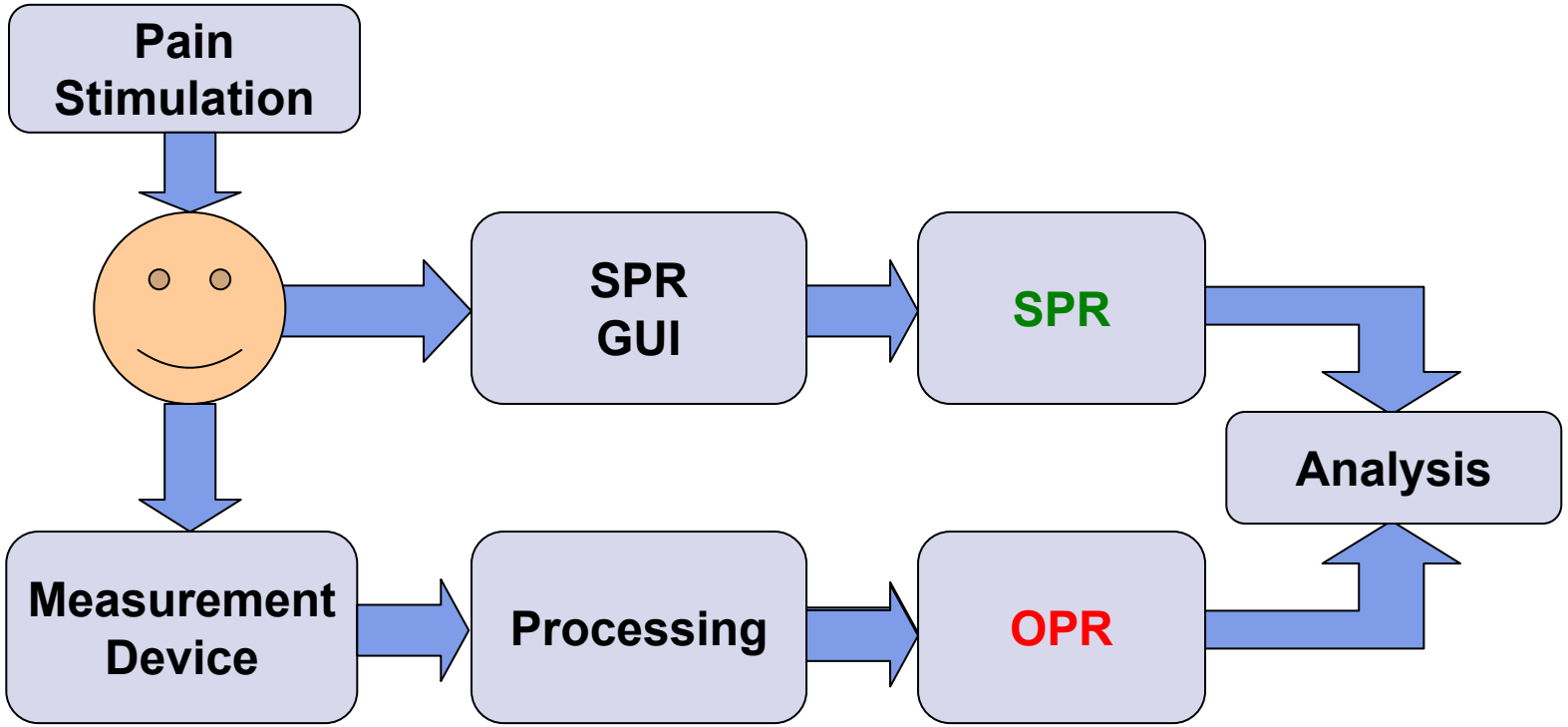

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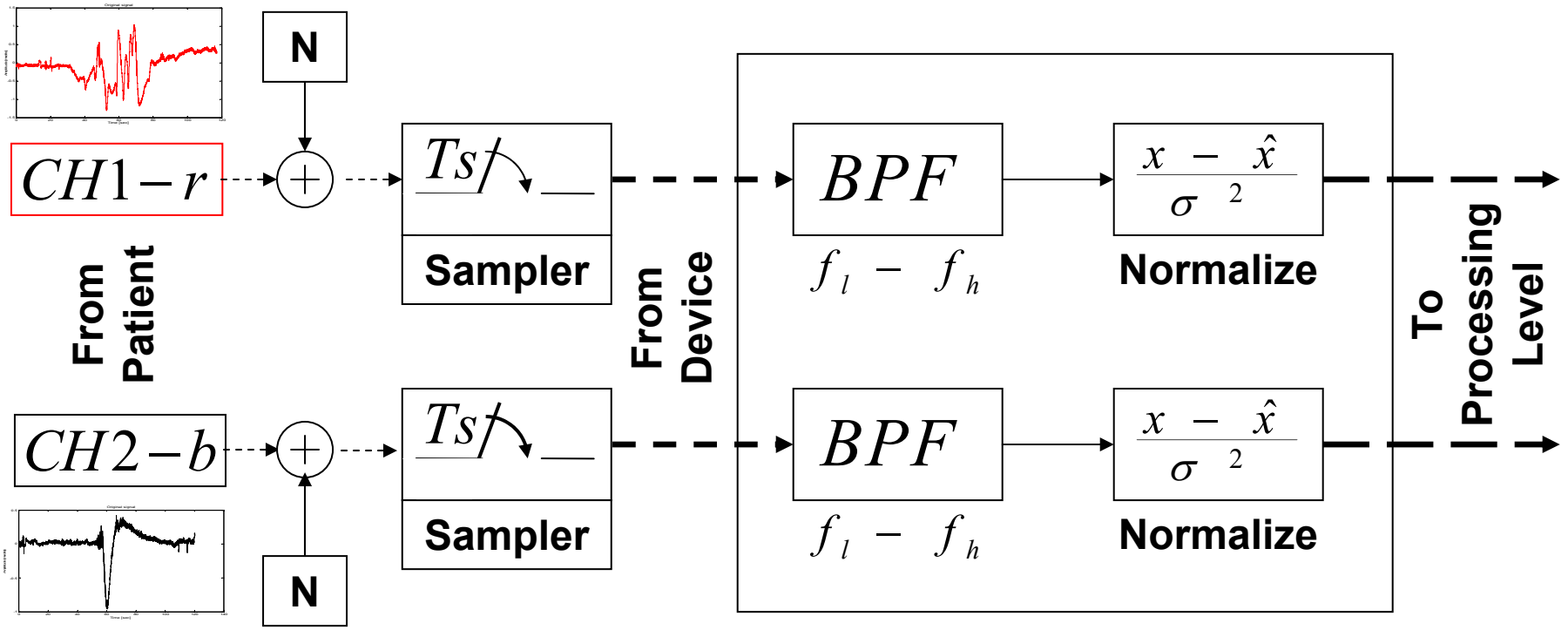
Preprocessing

MATLAB 6.5 implemented



$$Ts = \frac{1}{f_s} = 4\ [\text{msec}] \quad f_l = 0.5\ [Hz] \quad f_h = 5\ [Hz]$$

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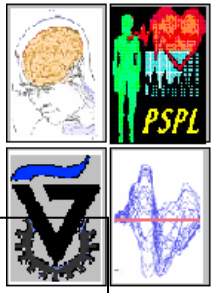
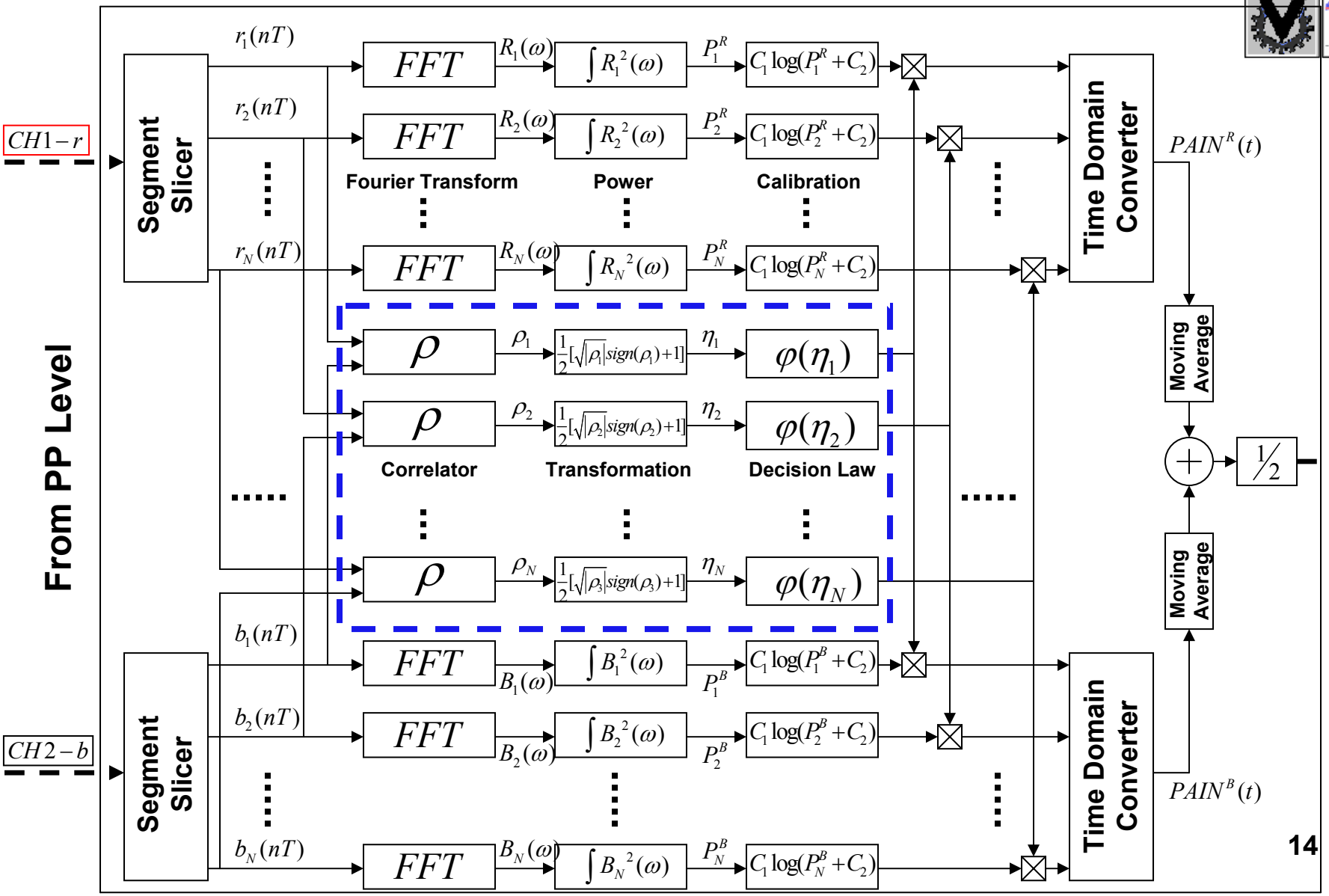
Processing





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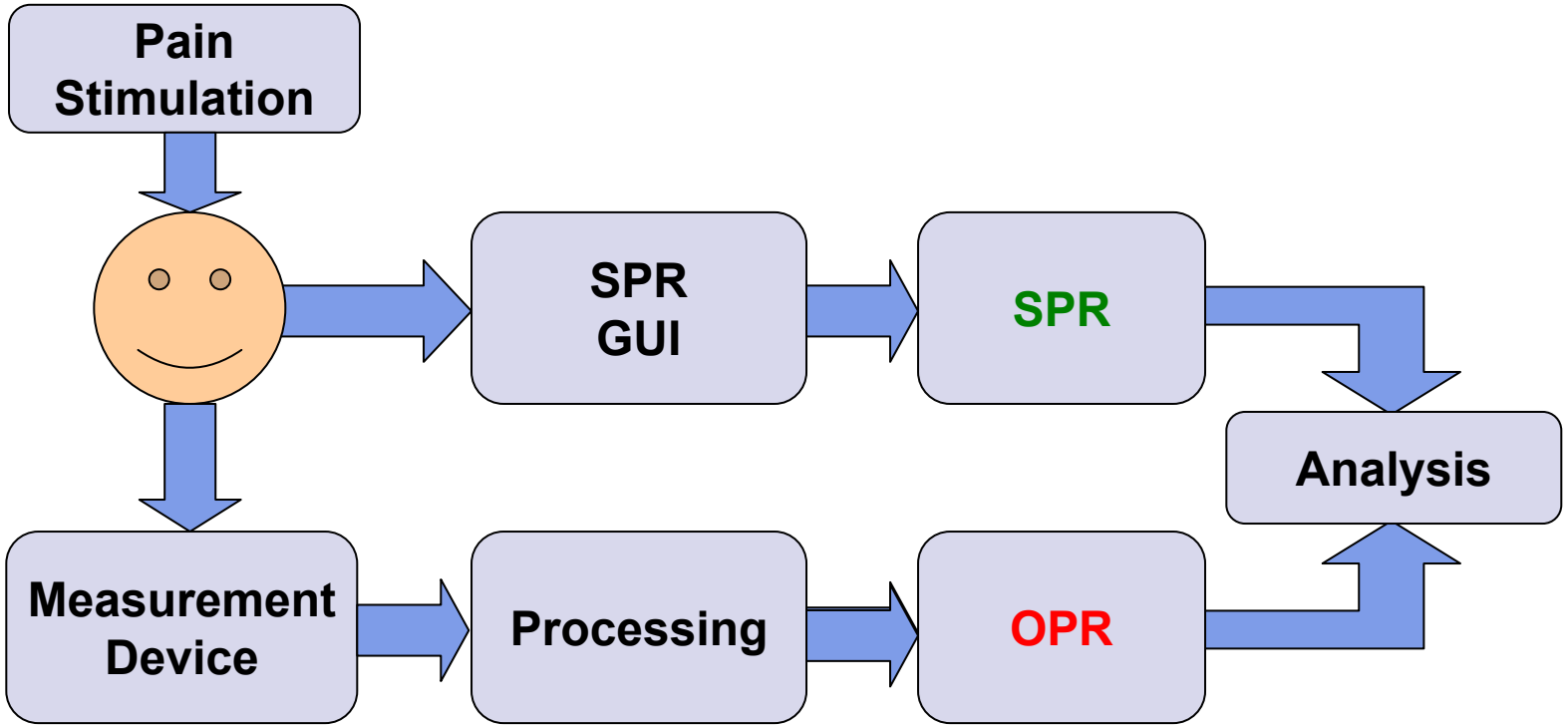

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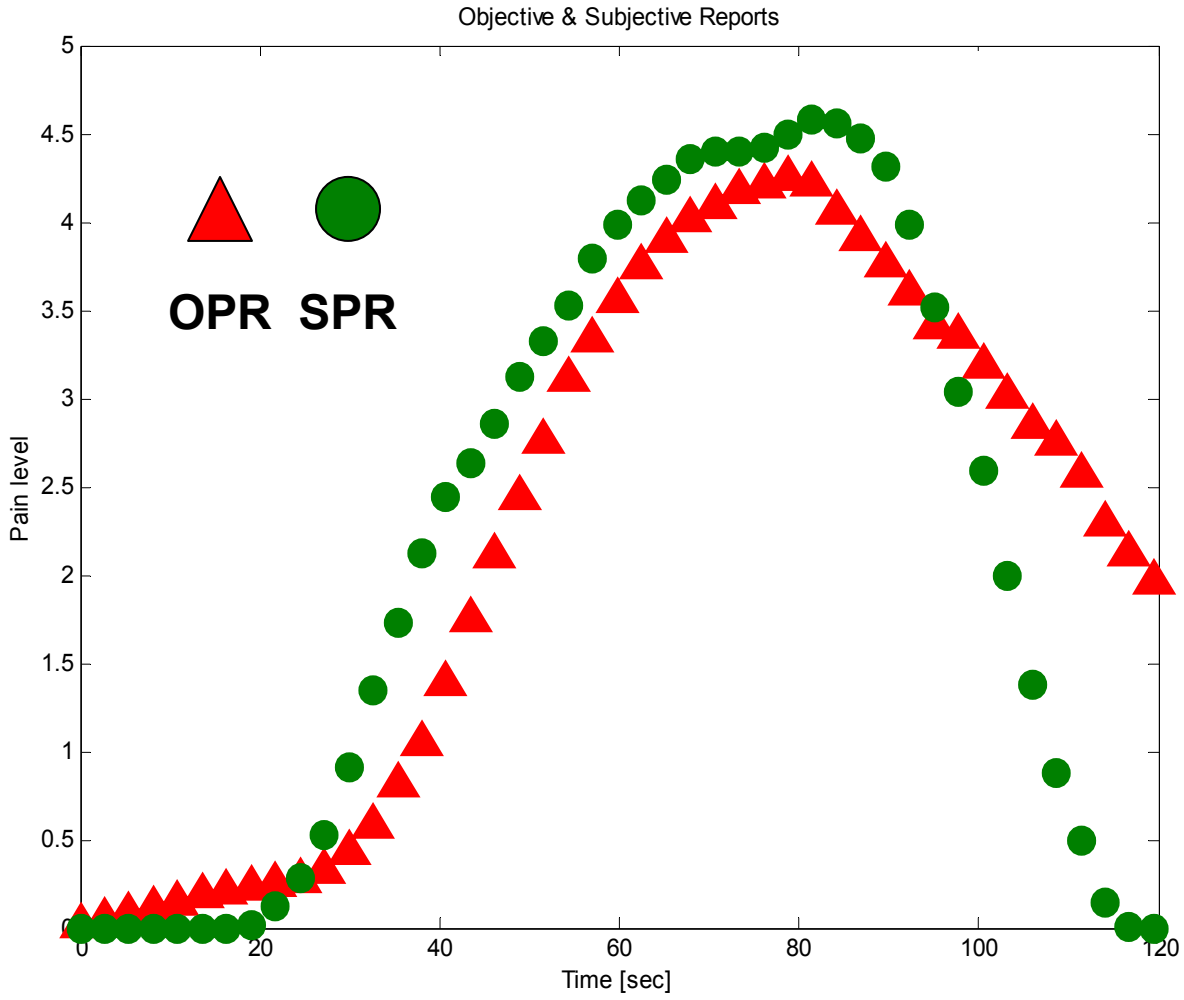
OPR VS SPR



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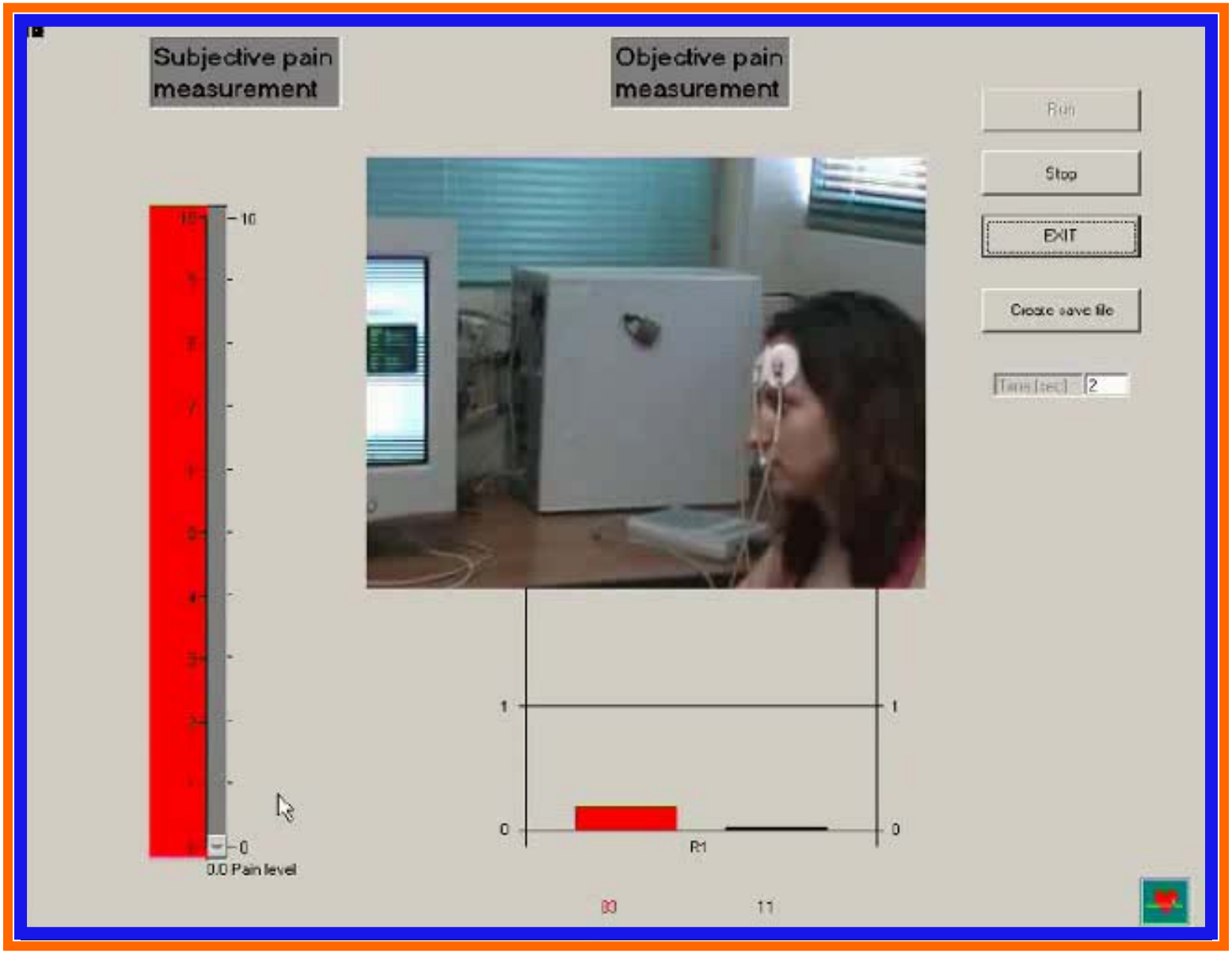

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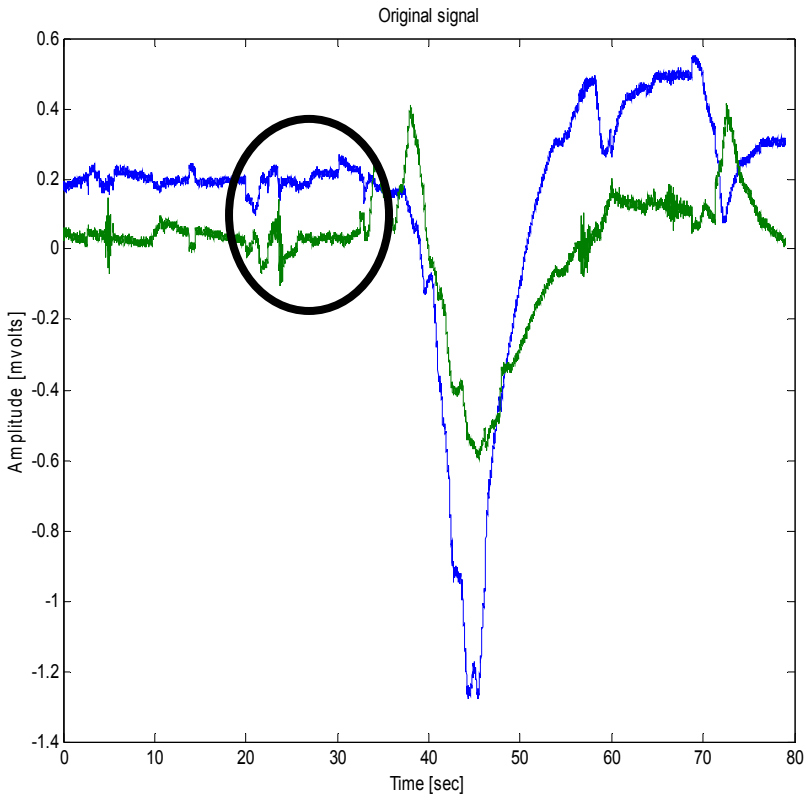
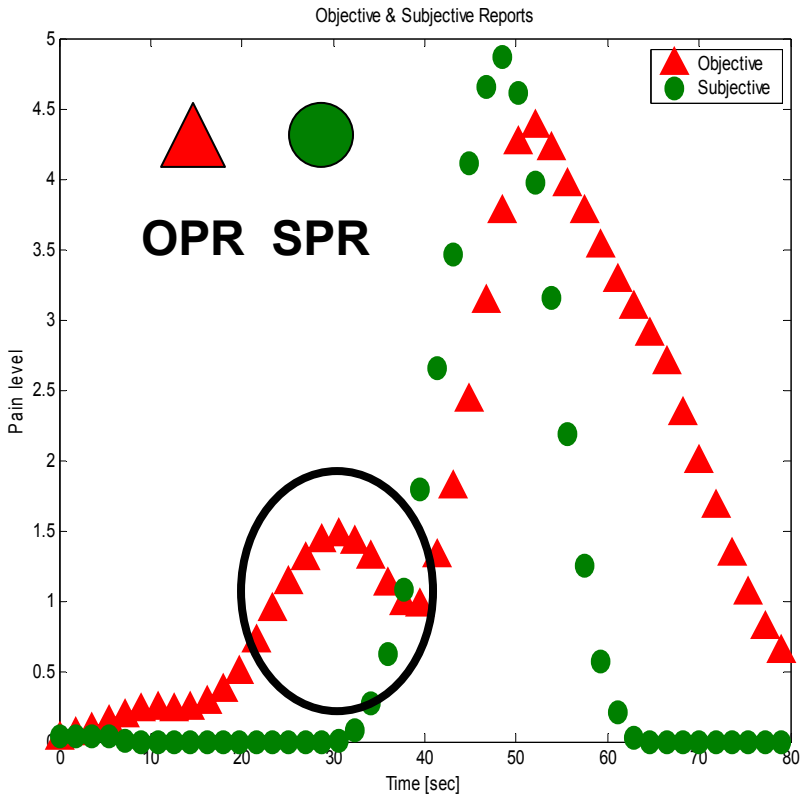
Results

Original Signal



OPR VS SPR



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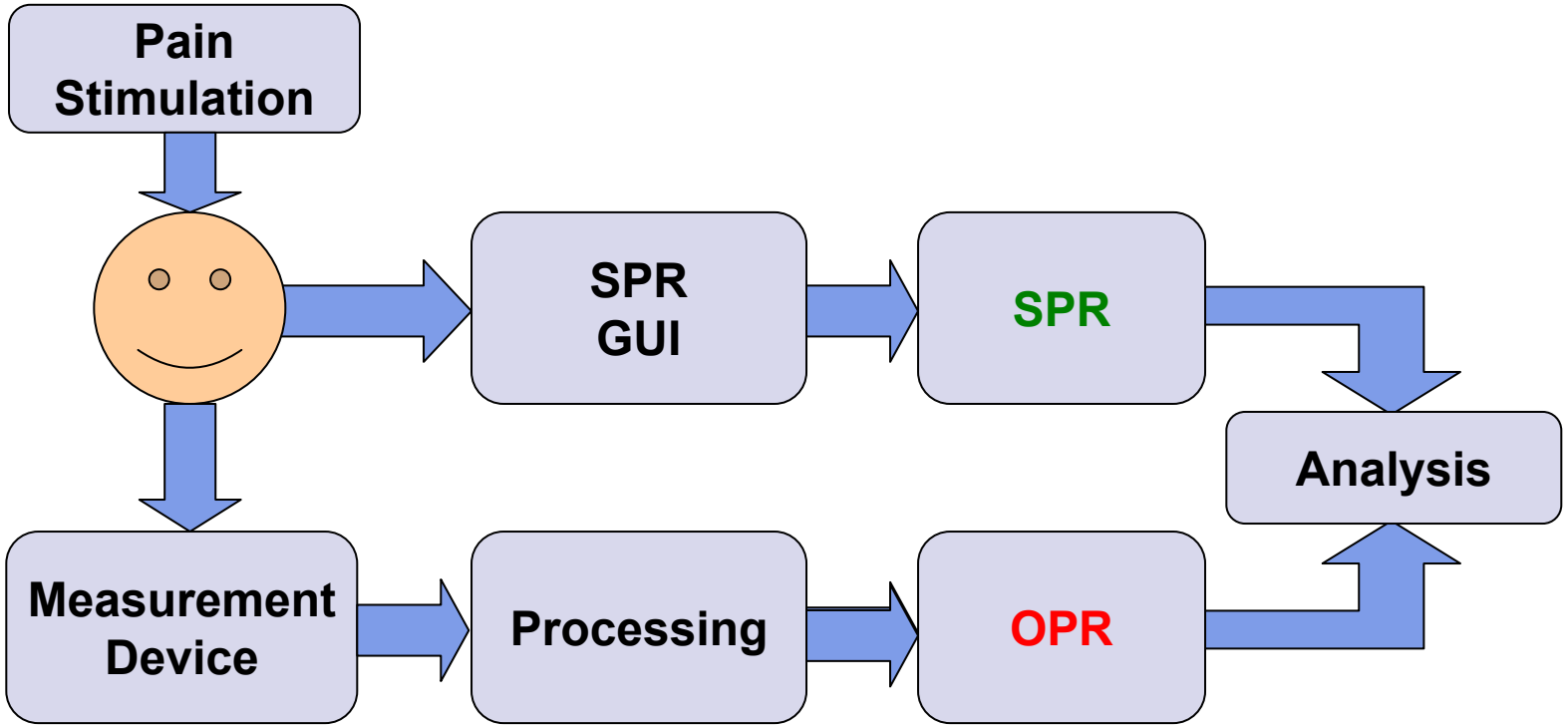

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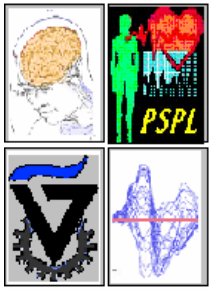
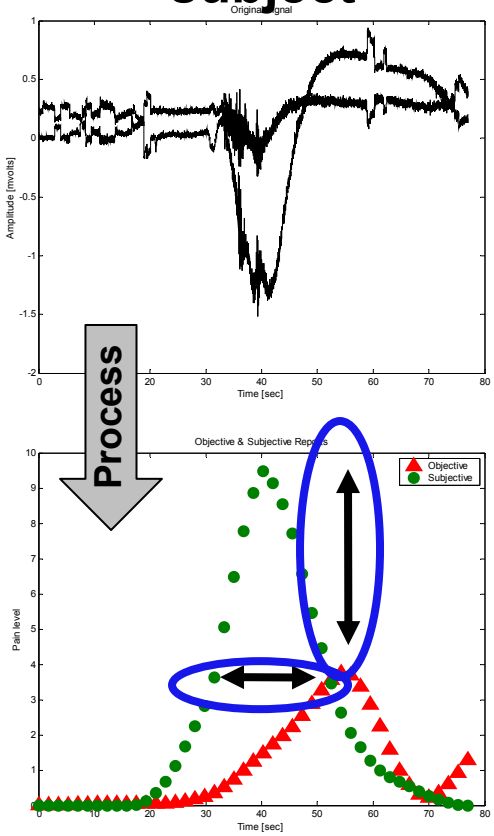
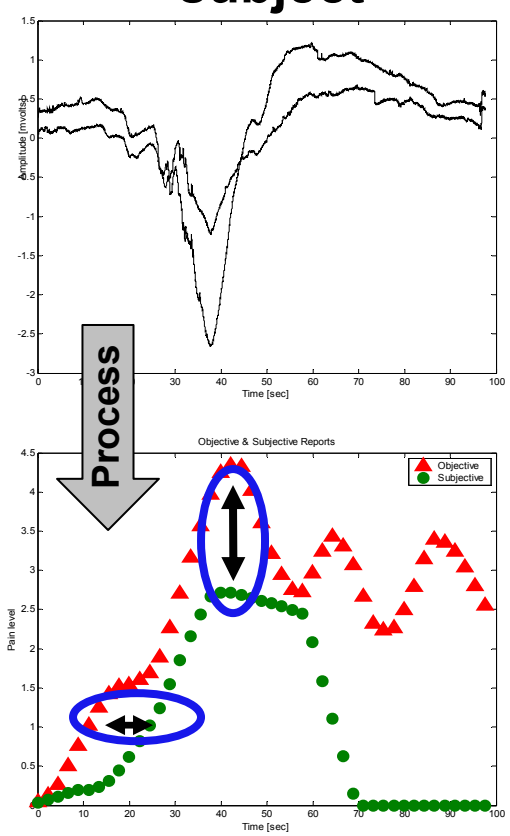


Personality Effect

“Sensitive” subject



“Insensitive” subject



Latency Effect

SPR OPR

Exaggeration

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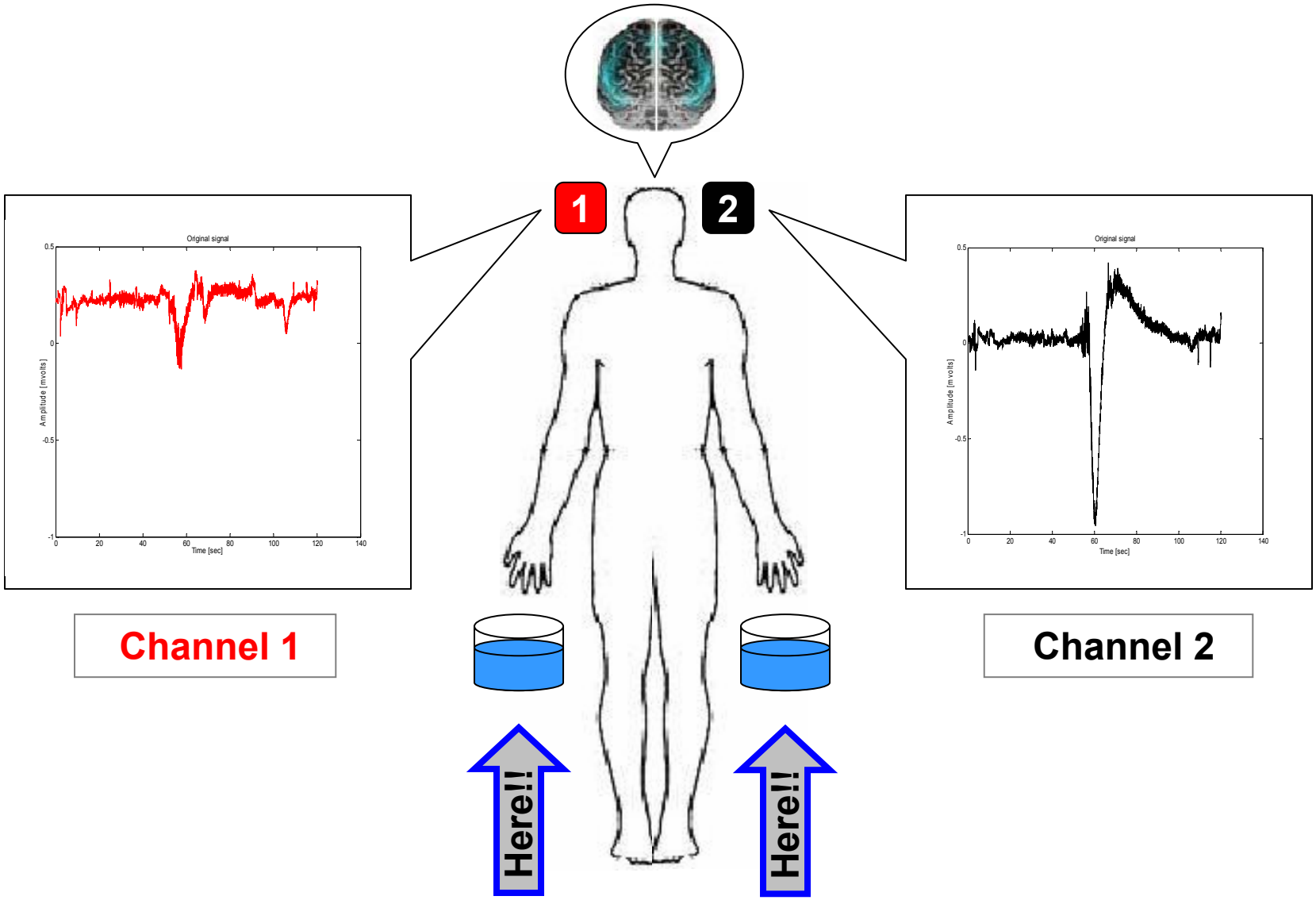
Laterality Effect



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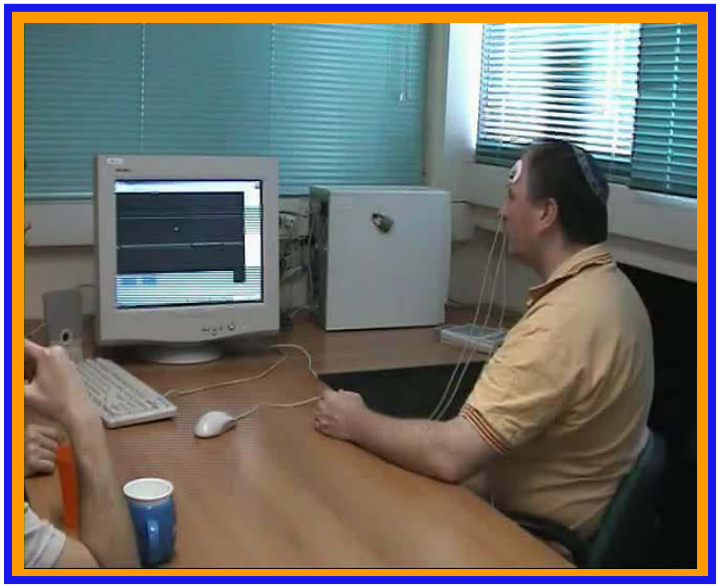
Difficulties



- **No references or analogs!**
- Lack of signal (**depressing!**)
- **Noise** – vital for small signals
- Experiment Protocol
- Processing & Calibration – from **scratch**
- **One semester project -** Time consuming experimentation

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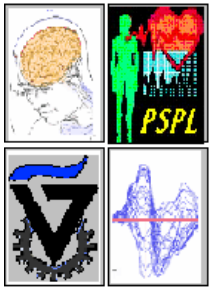
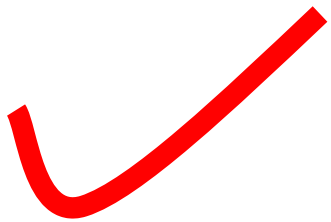


The Problem

Objective Pain measurement Possible?

YES!



<u>Goal</u> – Check feasibility of an objective pain measurement system

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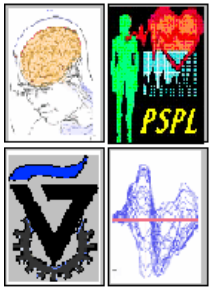

Conclusions

- Existence of signal **correlated** to pain
- Signal **dependence** on personal characteristics
- Processing allows **objective** pain assessment
- Pain signal **laterality**

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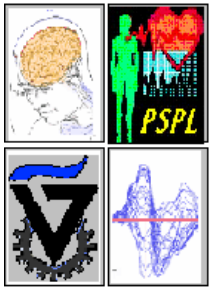

Further R&D

- Real-time OPR
- System calibration
- Pain source – internal/external
- Placebo effect
- Adaptation phenomenon
- Cooperation with Medicine faculty

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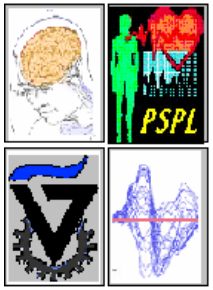
ΘΧΑΝΚΣ ΘΩ . . .

Oops!

Thanks to . . .

- Dr. Danny Lange - Supervisor
- Mr. Johanan Erez – PSPL Engineer
- The rest of PSPL staff
- All the students that volunteered to our experiments

End of slide show



Appendix

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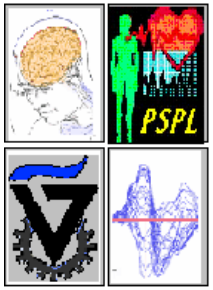

Parasympathetic nervous system

A part of nervous system that serves to slow the heart rate, increase the intestinal and gland activity, and relax the sphincter muscles. The parasympathetic nervous system, together with the sympathetic nervous system (that accelerates the heart rate, constricts blood vessels, and raises blood pressure), constitutes the autonomic nervous system.

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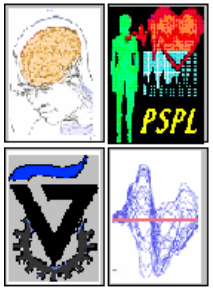

Processing Notes

- Two "relevance" parameters were examined

1. **Correlation** coefficient - ρ
2. **Coherence** function - $C_{xy}(\omega)$

$$\rho = \frac{COV(X,Y)}{\sqrt{Var(X) * Var(Y)}}$$

$$C_{xy}(\omega) = \frac{\left|P_{xy}(\omega)\right|^2}{P_{xx}(\omega) * P_{yy}(\omega)}$$

Relevance Index

Coherence found to have no relation to pain signal appearance

ρ

- Two power calculation methods were examined

1. **FFT** method - $F(\omega)$
2. **Linear Prediction** - $P_{xx}(\omega)$

$$X(k) = \sum_{j=1}^{N} x(j) * \omega_N^{(j-1)(k-1)}$$

$$x(n) = \sum_{i=1}^{P} a_i * x(n-i) + e(n)$$

Power computation Method

FFT, at this case, performed better than Linear Prediction

FFT

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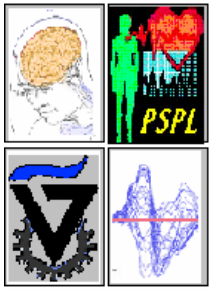
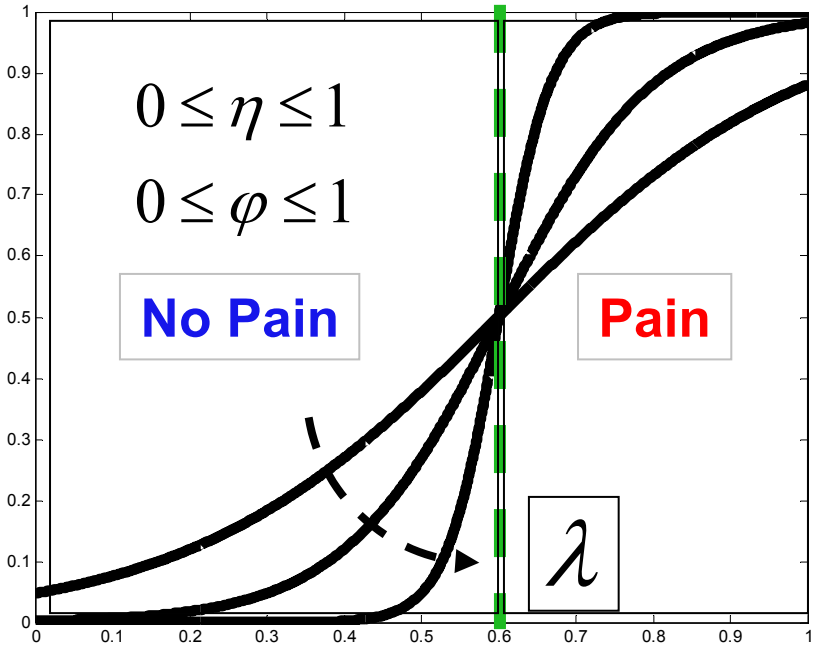


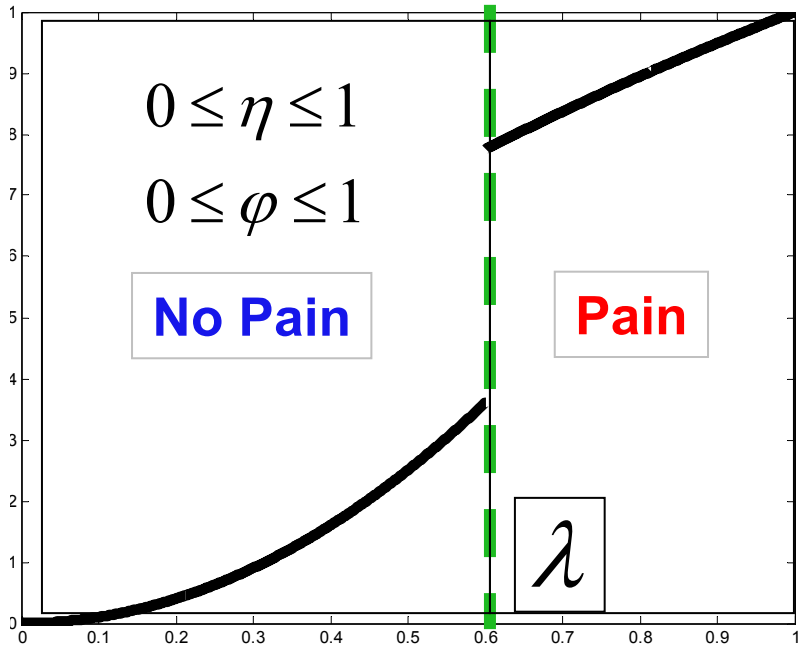
Decision Law

Possible



$$\varphi(\eta) = \frac{1}{e^{-\kappa(\eta-\lambda)} + 1}$$

Applied



$$\varphi(\eta) = \begin{cases} \sqrt{\eta} & for \quad \eta > \lambda \\ \eta^2 & for \quad \eta < \lambda \end{cases}$$

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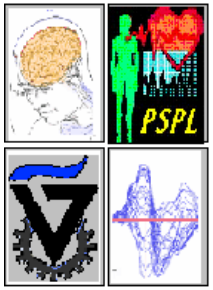

Calibration

- Obvious **signal dependence** on subject's Age, Gender etc.
- Leads to a **common approach** in medical equipment
- System calibrated with respect to **personal characteristics**
- Here, enabled by control over the **model parameters**:

$$\underbrace{C_1, C_2 - \text{Constants} \quad \lambda\text{- Decision Threshold}}_{\textbf{Empirically chosen}}$$